AN ABSTRACT OF THE THESIS OF

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Obesity is a major public health problem and is a risk factor for hypertension, diabetes, heart disease and cancer. In addition, the prevalence of obesity appears to be increasing worldwide, making it important to determine the nature and extent of obesity in populations at risk. The aim of this study was to determine the predictors of body mass index (BMI) in Taiwanese adults 19 through 44 years old. Independent variables from the Nutrition and Health Survey in Taiwan (NAHSIT) included biological factors (age and sex), dietary factors (energy intake and fat intake), environmental factors (educational level, residence area, and nutrition knowledge), and lifestyle factors (leisure time physical activity, smoking habits, and alcohol consumption). Results indicated that nearly 40% of the 1,182 adult survey participants were obese or overweight, by Taiwanese standards. Regression analysis found that significant predictors of BMI were residence area, educational level, and age. Taiwanese adults more likely to have higher BMIs were from the mountainous area, had less education. An increase in ten years of age was related to an average increase in BMI of 1.13 kg/m^2 ($p< 0.0001$), controlling for other variables.

These three factors accounted for 21% of the variance in all adults (15% of the variance in men, and 28% of the variance in women). In addition, smoking was a predictor of higher BMI in males, and alcohol intake was a predictor for higher BMI in females. Energy intake, fat intake, leisure time physical activity, and nutrition knowledge were not significant predictors for either males or females. The findings from this study will help public health professionals identify target areas and program needs to reduce obesity in Taiwan, particularly in the mountainous areas where the prevalence of obesity/overweight was seventy percent.

Factors Associated with Body Mass Index among Young Adults in Taiwan

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CHAPTER 1
INTRODUCTION

1.1 Statement of the Problem

Obesity is a risk factor for hypertension, diabetes, heart disease and cancer. The prevalence of obesity appears to be increasing worldwide, making obesity become one of the acknowledged public health crises. This study incorporated social factors aims to determine the nature and extent of obesity in Taiwanese adults, unlike the current Taiwanese obese studies that mainly focus on biomedical factors.

Obesity has been recognized as a critical risk factor for a number of diseases including Type II diabetes, cardiovascular disease, hypertension, gallstones and certain cancers. The association between obesity and chronic diseases has been documented in the literature (WHO 1998; Ng, Kim-choy, Lin, Cheng-chieh, Lai. Shih-wei 2001; Liu, Mei-yuan., Yeh, Sung-ling, Chen, Wei-jao , 1998). From a public health perspective, obesity contributed to more than 300,000 potentially avoidable deaths and accounted for more than $68 billion in direct health care expenditures each year in the United Sates, consuming more than 6% of the total US health care costs (Wolf, 1998 and Rippe, 1998).

From a personal health perspective, persons with a higher BMI have a greater chance of having an obesity-related co-morbidity in the United States (Rippe, 1998). Obesity may result in some social barriers and psychological problems in individuals as well (Kottke, T.E., Wu, C.A., Hoffman, R.S., 2003). Obesity and its related co-morbidity revealed heavy burdens to both societies and individuals.

Although obesity in the United States has been studied extensively, much remains to be learned about obesity in Taiwan. For example, at present there are no official statistics regarding the medical expenditures of obesity treatments or revenues from the related industries in Taiwan. However, there are indications from the Nutrition and Health Survey in Taiwan (NAHSIT) that 85% of people with a BMI $\geqq$ 27 had obesity-related metabolic disorders (Taiwan DOH, 2002). Therefore, obesity is a contemporary public health problem in the United States and in Taiwan as well.

The prevalence of overweight and obesity has been reported to be increasing globally (Flegal, Carroll, Kuczmarski and Johnson, 1998). For example, the prevalence of overweight and obesity for American adults was 64% according to the results of the 1999-2000 National Health and Nutrition Examination Survey (NHANES). This fact stands for a prevalence that is approximately eight percent higher than the estimated prevalence from the NHANES III (1988-1994) (National Center for Health Statistics, 2003). Other countries have reported a high prevalence of overweight and obesity as well. Overweight prevalence was 45% for Brazilian adults (Marins et al., 2001). In

Spain, the prevalence of overweight and obesity rose six to nine percent from 1987 to 1995/1997 (Artalejo, F.R., Garcia, E.L., 2002). In Taiwan, data from the NAHSIT-III suggested that the average body weight of adults increased 2 Kg when compared with the NAHSIT-II survey conducted ten years earlier (Kao, M.D., Tzeng, M.S., Yeh, W.T. et al., 1998). The prevalence of overweight and obesity in all adults was higher than 30%, using 2002 Taiwanese standard (BMI ≧ 24).

BMI is commonly used to classify obesity. Higher BMI is also a risk factor for hypertension and cardiovascular diseases (Reddy, 1998) and is an indicator of standard of living in developing countries (Nube, et al., 1998).

Obesity is the product of an imbalance between energy input and energy output. Many factors are believed to contribute to obesity, including genetics, energy intake, physical activity, and behavioral and environmental factors. Genetics only account for 25% to 40% of inter-individual difference in obesity (Maffeis, 2000). In most cases, genes involved in weight gain do not directly cause obesity but they increase the susceptibility to excess body fat storage in persons exposed to a specific environment (Maffeis, 2000). Some of the risk factors for higher BMI include age, sex, energy intake, physical activity, socioeconomic status, tobacco use, and alcohol consumption (Artalejo, F.R., 2002; Paeratakul, S., Popkin, B.M. et al. 1998; Marins, 2001 and Sobal and Stunkard, 1989). However, the relationship between obesity and identified risk factors is very complex and not fully understood (Stunkard and Sorensen, 1993).

Biomedical perspectives have dominated obesity research including research done in Taiwan, especially in obesity etiology and treatment. However, little research has addressed the obesity problem from a social perspective, understanding the nature and extent of the effects of socioeconomic and behavioral variables on obesity in Taiwan. Obesity research using only biological factors and dietary factors ignores the impact of the social and cultural factors on obesity. In addition, there is evidence that the prevalence of overweight and obesity varies across socioeconomic strata and places of residence (urban vs. rural area) in other countries (Sobal and Stunkard, 1989 and International Diabetes Institute, 2000).

Therefore, this study used the NAHSIT-III data to explore biological, dietary, environmental, and lifestyle factors that may predict BMI in Taiwanese adults aged 19 to 44 years. This study focused on a population of young adults living in Taiwan. The aims of this study were to determine the prevalence of overweight and obesity among subsets of the sample population, and to examine potential predictors of BMI in young adults in Taiwan.

Obesity is an acknowledged public health problem. Also, the prevalence of obesity is increasing globally. Obesity is an emerging public health crisis in Taiwan as well. Currently, biomedical approach dominates obesity research in Taiwan, which ignores the impact of the social factors on obesity. This study aims to fill the gap and is expected to provide useful information on obesity intervention planning and obesity policy making.

1.2 Research Questions

This study focuses on the following questions:

1. Among age, sex, educational level, area of residence, leisure time physical activity, nutrition knowledge, energy intake, fat intake, smoking habits, and alcohol consumption, what factors can predict BMI in young adults in Taiwan?

2. Does the predicting model for BMI in the sample population vary by gender?

3. Does BMI increase with age in the sample population?

4. Is alcohol consumption related to an increase in BMI?

5. Is area of residence associated with alcohol consumption?

6. Is area of residence related to BMI, energy intake, fat intake, leisure time physical activity, and/or nutrition knowledge?

7. Are smoking habits associated with energy intake?

1.3 Delimitations of this Study

The participants of the survey were sampled from the residents of Taiwan who were aged four and above. Due to the different determinants of obesity and variation of dietary intake and physical activity patterns for children, adolescences, adults and elders, this study only focused on adults aged 19 to 44 years. I chose this age group for three reasons: first, obesity in adulthood has a relatively stronger correlation with chronic diseases than younger age groups. Second, adults have crucial influences on children and elders in many aspects of daily life. Finally, the age group of 19 to 44 years old had higher increased rates of body weight than the age group of 45 to 64 years old when compared to the earlier data. For example, the average body weight increased 2.1 kg while the average height decreased 0.8 cm for men in the 19~44 age group; the average body weight increased 2.8 kg while the average height decreased 0.7 cm for women in the 19~44 age group. Therefore, it is more imperative to study obesity in this age group of adults in Taiwan.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview of this Chapter

The first aim of this study is to determine the prevalence of overweight and obesity among young adults in Taiwan. However, the criteria of obesity adopted will influence the magnitude of prevalence. Therefore, this chapter will first discuss the suitable definition of obesity for Taiwanese populations, referring to the extensively used international criteria.

Many risk factors related to obesity have been identified, including biological, dietary, lifestyle, and environmental factors. However, the relationships between these factors have been acknowledged to be complex. For example, the relationships seemed to vary in different populations. The second aim of this study is to examine potential predictors of BMI in young adults in Taiwan. Therefore, this chapter will follow by reviewing the current literature and integrate the existing recommendations of predictors to guide this study.

Socioeconomic status (SES) has been recognized to greatly influence individuals' body weight in many countries. Consequently, this chapter will also review the earlier studies, and summarize the relationships between SES and obesity and the measurement issues of SES, in order to guide and support this Taiwanese study.

2.2 Criteria of Obesity

The prevalence of overweight and obesity has been reported to be increasing globally. However, the magnitude of prevalence depends on the criteria of obesity adopted. Most countries have adopted the criteria of obesity developed by World Health Organization (WHO) in order to achieve the objective of international comparisons. Before applying this idea, one may have to consider whether the criteria of obesity fit all populations worldwide, and are able to effectively indicate the extent of risks for a specific population.

The WHO devised the classification of obesity based on the association between BMI and mortality from Caucasian populations studies (WHO, 1995 and 1998). The association curve for Caucasians was found to be a "J" shape for which the nadir occurs between BMI = 18.5 to 25 (Stevens, J. et al., 1998). From that most Western countries, including the United States, adopted the following definition recommended by WHO: overweight (BMI$\geqq$25.0); pre-obese (BMI 25.0-29.9); class I obesity (BMI 30.0-34.9); class II obesity (BMI 35.0-39.9); and class III obesity (BMI$\geqq$40.0) (Flegal, K.M. et al., 1998). A standardized definition of obesity facilitates international comparisons. However, this notion is based on an assumption that different ethnic groups have similar risks of morbidity and mortality at similar levels of BMI. If this assumption were incorrect, the interpretation of international comparisons would be problematic (Bell, A. et al., 2002). Therefore, the suggestion is that obesity should include the association with ethnicity.

This is the case for Taiwan. There is much evidence that supports a different definition of obesity in Taiwan. A study of Asian populations suggested that Asians have a higher prevalence of chronic diseases at lower BMI levels than Caucasians. This study also recommended that overweight status for Asian adults should be based on a BMI of 23.0-24.9 (International Diabetes Institute, 2000). The Bell et al. study supported this idea for Chinese populations but not for all Asian groups (Bell, A. et al., 2002). In addition, the average body fat content of Caucasians at BMI level of 30 corresponds to that of Chinese at BMI level of 27 (DHO, Taiwan, 2002). This phenomenon is probably because Asians have smaller frames than Caucasians (Deurenberg, P. et al, 1998 and 1999). Furthermore, findings of the Nutrition and Health Survey in Taiwan (NAHSIT) suggested that 85% of adults at BMI $\geqq$ 27 have some obesity related metabolic disorders; and, 65% of female adults and 68% of male adults at BMI $\geqq$ 24 have some obesity related metabolic disorders (DOH, Taiwan, 2002). Based on these reasons, the Taiwan Department of Health declared that the cut-off points for overweight and obesity in Taiwan are BMI = 24 and BMI = 27, respectively.

2.3 Relevant Studies on Obesity / BMI and Its Related Risk Factors

A Spanish study used its three national health surveys data (from 1987 to 1997) to predict the risk factors of BMI (Artalejo, F.R. et al., 2002). The numbers of participants in three surveys were respectively 17,434, 4,736, and 4,678 individuals aged 16 years and above. Age and marital status were found to have a positive relationship with increased BMI for all participants. Smoking habits, leisure time physical activity, and education had an inverse relationship with increased BMI for all participants, although the relationship between smoking and BMI was weak. Physical activity at work and alcohol consumption had small or null contribution to overweight and obesity. The author thought energy intake had not increased in the last decade in developed countries, so that he did not take dietary factors into account. However, eating patterns have changed in developed countries, such as increased fat intake and decreased intake of carbohydrates. Also, BMI was based on a self-reported data, not from an anthropometric measurement. There was no precise measurement of physical activity as well. All these factors could bias the study results.

A study analyzed data from the 1989 and 1991 China Health and Nutrition Surveys (Paeratakul, S. et al., 1998). It compared the results of a prospective study and a cross-sectional study. Three thousand four hundred eighty four adults aged 20-45 years were in the baseline survey. For all participants, fat intake, energy intake, age, female, and urban residence had a direct relationship with higher BMI in a multiple regression model, while education and physical activity had an inverse relationship with increased BMI. Smoking habits had no significant association with BMI, possibly due to limited data on tobacco consumption. Alcohol consumption was not considered in this study. The strength of this study was its careful measurements on dietary intake. Three consecutive 24-hour dietary recalls were applied to reduce possible measurement errors derived from a random fluctuation in day-to-day intake.

Household food consumption, determined from inventory change, was used to check individual's dietary recall. If significant discrepancies were found, those households would be revisited.

Another study using the same Chinese population examined the dietary and environmental correlations of obesity (Popkin, B.M. et al., 1995). Most variables, including age, sex, fat intake, intake of non-fat source, income, and residence, were found to have a positively significant association with higher BMI. Physical activity and smoking habits, on the other hand, had an inverse relationship. Total energy intake was not a significant attribute of obesity. This study suggested that fat intake was a better predictor of BMI than energy intake. Physical activity was associated with energy intake in this sample. People with higher physical activity level consumed 265 kcal more per day than their counterparts, on average. Finally, educational level and alcohol consumption were not considered in this study.

Analysis of The WHO MONICA (Monitoring Trends and Determinants in Cardiovascular Disease) Project examined the relationship between BMI and educational level in 26 populations and suggested an inverse relationship between educational level and BMI for all women populations and half of men populations in affluent societies (Molarius, A. et al, 2000). This study includes developed and developing countries. The sample size of the first and second cross-sectional survey was 42,000 participants and 35,000 participants, respectively. Smoking habits failed to explain the education-BMI relationship in this study. Failure to control possible confounders, such as dietary factors, physical activity, and alcohol consumption could present a weakness. Also, the author suggested that incorporating income and occupation might be better indicators of socioeconomic status than a single indicator such as education, but they did not have those data.

An Indian study used occupation-related physical activity, smoking habits, and income to predict BMI in different ethnic groups (Reddy, B.N., 1998). Income was found to have a significantly positive relationship with increased BMI, individually accounting for 24% of variance in men. Age was found to have a non-linear relationship with BMI, accounting for 5~7% of variance. Mean BMI shows a gradual increase until the age of 50, and then followed by a decline. Physical activity had an inverse relationship with higher BMI and smoking habits had no significant contribution of explaining BMI. No control of education and alcohol consumption and no quantitative food consumption data in this study represented a weakness.

A study in Brazil recruited 1,455 men and 1,906 women aged 20 years and above (Marins, V.M. et al., 2001). The purpose of this study was to predict BMI and WHR (Waist-to-Hip Ratio) using dietary factors, socioeconomic factors, and lifestyle variables. Only age and years of schooling were found to have a positive relationship with increased BMI, and smoking habits had a negative relationship with higher BMI. More variables were selected to predict WHR, including age, sex, schooling, income, physical activity at work, and occupation. The author mentioned that physical activity at work and occupation were related to abdominal obesity. This is a possible reason for not being able to predict BMI since BMI does not take into account fat distribution. The reason that dietary factors failed to predict BMI could result from obese participants' under-reporting and dieting behaviors other than measurement issues.

The Dryson et al. study found an inverse association between socioeconomic status and BMI among European groups rather than other ethnic groups in New Zealand (Dryson, E. et al, 1992). Among three socioeconomic indicators, family income failed to predict BMI in a multiple regression model. The author concluded that ethnic variation were partly explained by educational levels and occupation, however, only accounting for 2~3 % of variation. Another study used the U.S. Hispanic populations to examine the relationship between acculturation and obesity, controlling for socioeconomic status (Khan, L.K. et al., 1997). Unexpectedly, BMI was not associated with socioeconomic status. The author explained that measurement of socioeconomic variables is inherently difficult, particularly in multicultural or multilinguistic comparisons.

Diet and nutrition knowledge has been found to be related to food intake. A positive correlation between nutrition knowledge score and dietary variables such as energy, carbohydrate, protein, fiber, and some nutrients was found. However, the relationship was weak (Steyn, N.P. et al., 2000). Also, looking at urban-rural discrepancies, no differences were found in this study because the nutrition knowledge scores were low in both. The Charny and Lewis study also found an association between health knowledge and food consumption (Charny,

M. and Lewis. P.A., 1987), although the relationship was weak as well. In contrast, the Shepherd and Stockley study failed to find a relationship between nutrition knowledge and fat consumption (Shepherd, R. et al., 1987). However, there were only three questions on the knowledge test in this study, it may have lost the precision.

2.4 Summary of Studies: Related Risk Factors of Obesity

From the above review studies, some conclusions can be drawn. Age, sex, energy intake, fat intake, physical activity, education, income, occupation, area of residence, smoking habits, and alcohol consumption were used to predict BMI for both explanatory and controlling purposes. Age was positively related to increased BMI and had a non-linear relationship with BMI. The relationship models usually differed by sex. Therefore, it is recommended to perform gender-specific analyses separately. Energy intake was found to have a direct relationship with increased BMI in a Chinese study. Moreover, the two Chinese studies found that fat intake was a stronger predictor of BMI than energy intake. Also, measurement issues of dietary variables could contribute greatly to the results.

Physical activity was mostly found to have an inverse relationship with higher BMI. Educational level had a negative relationship with increased BMI in most studies, but the Brazilian study found a positive association. Income was found to have a positive relationship with higher BMI in developing countries. However, some national health surveys did not collect the income data. Urban-rural differences in the relationship between dietary factors and BMI were found in the Chinese study. Some studies did not consider this factor. Three studies found an inverse relationship between smoking habits and BMI. However, one study reported the relationship was weak. On the other hand, another three studies failed to find an association between smoking habits and BMI. Most studies did not take into account of alcohol consumption. The only two studies that considered alcohol consumption failed to find an association between alcohol consumption and BMI. Nutrition knowledge was found to have a weak relationship with dietary intake, but was not considered in the predicting models of the six major studies.

In summary, BMI is mainly influenced by biological factors (age, sex, ethnicity etc.), dietary factors (total energy intake and fat intake), environmental factors (education, income, occupation, area of residence), and lifestyle factors (physical activity and tobacco use).

2.5 Socioeconomic Status and Obesity

Among many factors that may influence individuals' body weight, SES is usually beyond individuals' control. However, something could be done at a societal level if the relationship between SES and obesity were well understood. Plenty of studies have been done to determine the relationship between SES and obesity. However, the relationship is varied by society types. In developed countries or affluent societies, SES and obesity reveals a strong inverse relationship among women. However, the relationship is inconsistent for men and children. In developing countries, on the other hand, a strong positive relationship occurs between SES and obesity among women, men, and children (Sobal, J. and Stunkard, A.J., 1989).

Although many significant associations between SES and obesity were found, no further conclusion could be drawn. The relationship between SES and obesity could be bi-directional or influenced by a third factor (Stunkard, A.J. et al., 1993). Some possible mechanisms were suggested: (1) Income may influence the body weight through the resources of foods that individuals can obtain (Khan, L.K. et al., 1997). In developing countries, high-income groups have higher intake of fat and animal products (Paeratakul, S. et al, 1998). Since chronic energy deficiency is a serious nutritional problem in the majority of populations in developing countries, this phenomenon is not surprising. The situation could be reversed in developed countries. (2) Education may influence the body weight through knowledge (Khan, L.K. et al., 1997). To some extent, educational level is related to income level (Nube, M. et al, 1998). Better education is related to physically less demanding jobs (Nube, M. et al, 1998). (3) Social and cultural norms may influence the "desirable weight" and norms vary by population, sex, age, and SES (Molarius, A. et al., 2000). In developed countries, the highest SES group often wants a lifestyle of balancing energy input and energy output, so that the desirable weight is lower than that of their counterparts (Artalejo, F.R., et al., 2002). In developing countries, the highest SES group may think that obesity is harmless and is a symbol of richness (Popkin, B.M. et al., 1995). Therefore, the desirable weight may be higher than that in developed countries.

One other difficulty with SES as a predictor is its conceptualization and measurement. The indicators of SES are inconsistent in the literature. Income level and educational level are usually used while occupation is less often used. Most studies used only one measure such as education or income (Sobal, J. and Stunkard, A.J., 1989). Thus, "The measurement procedure may determine the significance and strength of the SES-obesity relationship reported in a study, and the relationship between SES and obesity may differ according to the measure of SES or obesity used." (Sobal, J. and Stunkard, A.J., 1989) The suggestion is that it is better to use multiple measures. However, many studies failed to develop a composite measurement of SES due to the realistic limitations of studies, such as lack of data needed.

2.6 Possible Predictors of BMI: Methods for this Study

According to the literature review, possible predictors of BMI include age, sex, energy intake, fat intake, physical activity, educational level, income, occupation, area of residence, marital status, smoking habits, alcohol consumption, and nutrition knowledge. However, there is no income data in the NAHSIT. Educational level or occupation could be used as an indicator of SES. Multiple regression models are appropriate statistical methods for this cross-sectional study. Gender-specific analyses for predicting BMI were recommended in the literatures.

CHAPTER 3
RESEARCH METHOD

3.1 Introduction of the Research Methods and Rationale

This study aims to examine the predictors of BMI in adults between the ages of 19 to 44 years in Taiwan. The study variables, representing predictors, include age, sex, educational level, area of residence, leisure time physical activity, energy intake, nutrition knowledge, smoking habits, and alcohol consumption behaviors. These data were collected in the third Nutrition and Health Survey in Taiwan (NAHSIT) conducted in 1993 to 1996. A cross-sectional household interview survey and health examination was used to collect the data. The data set[1] used in this study was obtained from the Office of Survey Research, Academia Sinica, Taiwan.

Occupational data was collected in the NAHSIT, but was excluded by this study for the reason stated below. The initial occupational data was classified into nine categories and there were nine subcategories under each category. Each category mixed white-collar and blue-collar jobs together and was difficult to classify the data based on physical activity level.

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[1] Data analyzed in this study were collected by the research project "Nutrition and Health Survey in Taiwan" sponsored by the Department of Health in Taiwan (DOH FN8202, DOH-83-FS-41, DOH-84-FS-11, DOH-85-FS-11, DOH-86-FS-11) . This research project was carried out by Institute of Biomedical Sciences, Academia Sinica, and directed by Dr. Wen-Harn Pan et al. The Office of Survey Research of Academia Sinica is responsible for the data distribution.

3.2 Description of the Data Set

The National Nutrition Survey has been carried out in approximately 5-year intervals in Taiwan since 1980. The third Nutrition and Health Survey conducted from 1993 to 1996 broadened the content of National Nutrition Survey, including information on 24-hour dietary recall, food intake frequency, nutrition and health knowledge / attitude / practice, and disease history and symptoms. The data of the NAHSIT were collected by household interviews and health examination to evaluate nutrition and health status of Taiwanese. The NAHSIT was devised by biochemical and clinical approaches. Descriptions regarding participants, sampling method, instruments, and data collection and operation are presented in the following sections.

3.3 Sampling Method and Participants of the NAHSIT and this Study

The NAHSIT used a stratified and multiple-staged probability sampling design. All the 365 townships and city districts in Taiwan were stratified into seven strata according to cultural and lifestyle characteristics, degree of urbanization and geographical regions. The seven strata were Hakka area, mountainous area, east coast, Peng-Hu islands, metropolitan areas, provincial cities and class I townships, and class II rural townships. Hakka areas have a larger proportion of people who migrated to Taiwan a few hundred years ago from several counties of the Guangdong Province of China. (Lee CS, 1989)

Aborigines who reside in the highlands of central and eastern Taiwan are the major residents of the mountainous area. Residents of the two east coast counties live in the narrow plain of the east coast and are geographically separated from the west side of Taiwan by the barrier of the central mountains. Peng-Hu islands are the primary island group offshore of Taiwan in the Taiwan Strait. (Pan WH et al., 1999)

By applying the method of probability proportional to sizes, three townships or districts in each stratum were selected, within which three villages or city blocks were chosen. This gave a total of 63 villages or city blocks. In each sampled area, the researchers used a series of computer-generated random two-dimensional points to select an area including 75 households within 200 square meters. "Once the first household was selected, interviewers constructed a list of household addresses and demographic information of the household members for the next neighboring 75 households in the 200 square meters. Door-to-door visits were carried out to interview a designated number of people in each of the 14 age-sex groups (4-6, 7-12, 13-15, 16-18, 19-44, 45-64, and 65+). Seasonal effect was considered by separating a year into three seasons (Nov. to Feb., Mar. to Jun., and Jul. to Oct.) "A pseudo Latin square design was used to queue the survey sites to balance the seasonal effect. It was arranged in such a way that in a given season, seven villages or city blocks, each from one of the seven strata was visited. In addition, three villages or city blocks, balanced in season, each from one of the three townships or districts, have been visited in each stratum each year." (Pan

WH et al., 1999)

All residents of Taiwan aged 4 years and above who did not live in institutions were eligible for this survey. The target sample size was 10,080, and the final sample size was 9,962 (4,964 men and 4,998 women). The response rate for the household interviews was 74%. At the end of each household interview period, all respondents were invited to participate in a health examination. 6,464 individuals participated in the health examination. The response rate for the health examination was 65% within those who responded to the household interview (9,962 participants). (Pan WH et al., 1999)

In this study, only the age group of 19 to 44 was included. The sample size that received household interviews for this age group is 2,053 participants (1,013 men and 1,040 women). However, the BMI information of the participants was from the health examination. Only 1,183 participants (526 men and 657 women) within the 2,053 participants received the health examination. Therefore, the sample size of this study was 1,183. Possible bias could be introduced to this study in who refused to do the health examination.

3.4 Instruments of the NAHSIT and Data Used in this Study

The instruments used in the NAHSIT include household information and a general questionnaire, 24-hour dietary recall and food frequency questionnaires, cognition and behavior information questionnaires, and disease history questionnaires. All instruments of the NAHSIT were evaluated for validity and reliability in three pilot studies conducted from January to June in 1993 (Pan WH et al., 1999).

3.4.1 Household information and general questionnaire:

Questions on general and socio-demographic information, such as ID number, date of birth, place of birth, sex, marital status, ancestral origin, educational level, occupation, position, area of residence, and blood pressure and pulse, were included in this questionnaire.

3.4.2 24-hour dietary recall and food frequency questionnaires:

The 24-hour dietary recall was administered to participants aged 13 to 64 years. The participants were asked to report their dietary intake during the past 24 hours, including eating time, names and quantity of food, and types of food (raw or cooked). Food models, measuring cups or standard containers were used to appraise the amount of food intake. Specific food codes and measuring procedures were clearly illustrated in the interviewers' handbook (Pan, W.H., 1995). Detailed information regarding the operation of 24-hour dietary recall was published elsewhere (Pan, W.H., Chang, Y.H. et al., 1999). The food items and quantity consumed were major contributors and predictors of total calorie, protein, fat, and carbohydrate intake of each participant. The total energy intake of the participants in this study was retrieved from this section of the

NAHSIT data set.

Three forms of food consumption frequency questionnaires were developed for different age groups (4-12, 13-64, and 65 years old and above). The participants were asked to estimate the frequency of intake of 36 food items within 1 month prior to the interview. In addition, intake frequencies of deep-frying foods, soda, ice cream, and sugar were also assessed. Information on vegetarian preference and supplement use was included as well.

3.4.3 Cognition and behavior information questionnaires:

Cognition and behavior questionnaires were administered to participants aged seven and above. Three versions of questionnaires were devised for different age groups (7-12, 13-17, and 18 years old and above). Version 1 (for the age of 18 years and above) collected information on diet and nutrition knowledge, eating habits, diet and nutrition information sources, eating behaviors, physical activity, tobacco use, and alcohol consumption. Data of nutrition knowledge, leisure time physical activity, smoking habits, and alcohol consumption behaviors was used from this section of the NAHSIT data set.

3.4.4 Disease history questionnaires:

This questionnaire included two versions for two age groups (4-17 and 18 years and above). It collected information on diseases contracted, surgeries performed, medicine taken, some specific diseases of interest, and reproductive health. This study did not use any of this information.

3.4.5 Anthropometry

Anthropometry was one of the procedures in health examination in NAHSIT. Weight and height of participants was measured during health examination procedures by using the traditional standard method. Detailed information is available in Pan, W.H., 1995. BMI data used in this study was retrieved from this section of the NAHSIT data set.

3.5 Data Collection and Operation of the NAHSIT

The fieldwork of the survey was carried out for three years from July 1993 to June 1996. Twenty-one villages or city blocks were completed each year for a total of 63 villages or city blocks in three years. Quality assurance procedures were incorporated into every aspect of data collection. One-week training courses were provided to the potential interviewers who had a college degree in nutrition or related fields. Only those who passed the test were recruited as interviewers, and they were asked to attend re-training courses every six months. In addition, Record Sheets were designed for every operation and interviewers' manuals for each operational procedure were offered in order to ensure the quality of data collection (Pan, W.H., 1995). Procedures for on-site key-in and filling in missing data were designed for the 24-hour dietary recall. For other questionnaires, the team leader coordinated on-site crosschecking and correcting process. Also, double key-in procedure and logic checks by computers were carried out at the coordination center (Pan WH et al., 1999).

3.6 Procedures of Retrieving Data from the NAHSIT Data Set

The NAHSIT data set was obtained from the Office of Survey Research, Academia Sinica, Taiwan, in a SAS readable format. Data collected in different questionnaires was saved in separated files of the NAHSIT data set. Codebooks and information necessary for understanding the data were provided with the NAHSIT data set as well. All needed data for this study were merged by the participants' ID from several SAS data files by using the MERGE Procedure in SAS software. The criteria used in the MERGE Procedure were the age of the participants ranging from 19 to 44 and the participants with health examination. All data that failed to meet these criteria were excluded. After completion of the merge, some variables, such as BMI, age, sex, energy intake, and smoking habits, were ready for analyzing. However, others required further transformation, presented as followed:

Recoding processes

Educational level: The original data of educational level was collected in seven levels, including: (1) no education and illiteracy; (2) no education and somewhat literate; (3) primary school; (4) junior high school; (5) senior high school or occupational school; (6) college or university; (7) graduate school. The first three groups were combined as a new level labeled "primary school or lower". The last two groups were combined as a new level labeled "university or higher ". The other two groups remained the same.

Area of Residence: The original data of area of residence was collected in seven levels, as designed in sampling strategy, including: (1) Hakka area; (2) mountainous area; (3) east coast; (4) Peng-Hu islands; (5) metropolitan area; (6) provincial city and class I township; (7) class II rural township. Group (1), (5), (6), and (7) were combines as a new level labeled "western area". Group (3) and (4) were combined as a new level labeled "eastern and islands area". Group (2) remained the same. The rationale of recoding the area of residence data to three groups will be described in section 3.8.

Alcohol consumption: The question asked participants whether they had ever drunk alcohol. There were six answers: (1) never; (2) only tried one or two times; (3) had drunk over a short span but had quit; (4) seldom, but drank a lot every time; (5) sometimes; (6) often (once a week or more). The first three groups were combined as a new level labeled "non alcohol consumption". The last three answers were combined as a new level labeled "alcohol consumption".

Constructing composite variables

Leisure time physical activity: The information was collected in the cognition and behavior questionnaire. The question asked participants to estimate the frequency and duration of 8 physical activities they had done in the past one-month before the interview. If the participants had done some physical activities other than the listed items, there were two blanks they could fill out the type, frequency, and duration of physical activities. Physical activities that the participants reported were then coded to energy expenditure (Kcal) per kg (participants' body weight) per month. Each type of physical activity was assigned to a metabolic equivalent (MET) level to express its intensity according to the Compendium of Physical Activity, a standardized coding scheme developed by Ainsworth B.E. et al (Ainsworth, 1993) based on the MET. The initial variable names and labels in the NAHSIT data set were displayed in Table 1 with equivalent MET level[2] and its code number.

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[2] One MET is considered a resting metabolic rate measured during quiet sitting. One MET means it consumes 1 kcal per kg body weight per hour.

Table 1: Leisure Time Physical Activity and Its Equivalent MET Level

Variable	Label	Code	MET level
E1E1	Bike riding	01010	4.0
E1E4	Play ball	15050	6.0
E1E7	Gymnastics Calisthenics Tai Chi	15300 02030 15670	4.0 4.5 4.0
E1E10	Swimming	18310	6.0
E1E13	Dancing-Aerobic	03015	6.0
E1E16	Hiking	17080	6.0
E1E19	Jogging	12020	7.0
E1E22	Walking	17250	3.5
E1E25	Other 1 (average) About 40% push-up and sit-ups Others	02020	5.0 8.0 3.0
E1E29	Other 2 (average) 50% push-up and sit-ups Others	02020	5.5 8.0 3.0

Equation for calculating energy costs:

Energy cost (kcal / kg / month) = Frequency (times / month) * Duration (hour / time) * Intensity (MET)

Total energy expenditure (kcal / kg / month) = SUM of energy cost from each type of physical activity that the participants reported.

The calculation of energy expenditure was performed in Microsoft Excel.

<u>Nutrition knowledge</u>: There were nine questions regarding diet and nutrition knowledge in the survey questionnaire. Five multiple-choice questions asked participants: Which group of food contains higher cholesterol? What kind of

cooking oil is better for preventing cardiovascular diseases? Which group of food can prevent the problem of constipation? Which food has higher salt content and is suggested not to eat? What cooking method is the best for conserving vitamin C in vegetables? Four true or false questions asked participants: Childhood obesity is not a problem, so it doesn't matter. Obesity is highly correlated with the incidence of hypertension, heart disease, and diabetes. Eating more fast food such as hamburgers and fried chicken is good for health. It doesn't matter to your health whether you usually have breakfast or not. The nutrition knowledge score was determined by how many questions the participants answered correctly. Each correct response earned one point.

3.7 Proposed Research Questions and Variable Selection

In this study, the variables used to predict BMI encompass four categories: (1) biological factors (age and sex); (2) dietary factors (energy intake and fat intake); (3) environmental factors (educational level, area of residence, and nutrition knowledge); (4) lifestyle factors (leisure time physical activity, smoking habits, and alcohol consumption).

The proposed research questions were analyzed using different statistical methods appropriate for the response to each question. The following paragraphs describe each of the research questions and the methods of analysis.

Research Question 1: Among age, sex, educational level, area of residence, leisure time physical activity, nutrition knowledge, energy intake, fat intake, smoking habits, and alcohol consumption, what factors can predict BMI in young adults in Taiwan?

Research question one was analyzed using a multiple regression model. Twelve explanatory variables were used to predict BMI, the dependent variable. Five discrete variables, sex, educational level, area of residence, smoking habits, and alcohol consumption, were coded to dummy variables (1 = presence and 0 = absence) to create linearity between pairs of variables. (See Table 2)

Research Question 2: Does the predicting model for BMI in the sample population vary by gender?

Research question 2 was analyzed using two multiple regression models. In each gender-specific model, eleven explanatory variables were used to predict BMI, the dependent variable. Four discrete variables, educational level, area of residence, smoking habits, and alcohol consumption, were coded to dummy variables (1 = presence and 0 = absence) to create linearity between pairs of variables. (See Table 2)

Table 2

Definition and Measurement of Key Variables for Multiple Regression

Variable	Definition and Measurement	Scale	Continuous
BMI (Dependent Variable)	Weight in kg / height in m^2 Data gathered from health examination	Ratio	Yes
Female	Biologically determined Reference: Male 1=Female 0=Not female (male)	Nominal (Dichotomous)	No
Educational Level I	Education completed Reference: Primary school or lower 1=Senior high school or higher 0=Not senior high school or higher	Nominal (Dichotomous)	No
Educational Level II	Education completed Reference: Primary school or lower 1=Junior high school 0=Not junior high school	Nominal (Dichotomous)	No
Residence Area I	Household registered residence and actually live there Reference: Western area 1=Mountainous area 0=Not mountainous area	Nominal (Dichotomous)	No
Residence Area II	Household registered residence and actually live there Reference: Western area 1=Eastern and islands area 0=Not eastern and islands area	Nominal (Dichotomous)	No
Smoking Habits	Respondent reports 0=Non-smokers 1=Smokers	Nominal (Dichotomous)	No
Alcohol Consumption	Respondent reports 0=Non alcohol consumption 1=Alcohol consumption	Nominal (Dichotomous)	No
Leisure Time Physical Activity	Respondent reports and were converted to energy output (kcal) per kg (body weight) per month	Ratio	Yes

Table 2 continued

Definition and Measurement of Key Variables for Multiple Regression

Variable	Definition and Measurement	Scale	Continuous
Energy Intake	Data from 24-h dietary recall Unit: kcal / day	Ratio	Yes
Fat Intake	Data from 24-h dietary recall Percentage of energy intake	Ratio	Yes
Nutrition Knowledge Score	Count points that respondent answered nine general diet and nutrition knowledge questions correctly	Interval	No

Research Question 3: Does BMI increase with age in the sample population?

Research question 3 was analyzed using a bivariate correlation and a multiple regression model. BMI, the dependent variable, was used to examine the explanatory variable, age, controlling for all other variables. Five discrete variables, sex, educational level, area of residence, smoking habits, and alcohol consumption, were coded to dummy variables (1 = presence and 0 = absence) to create linearity between pairs of variables. (See Table 2)

Research Question 4: Is alcohol consumption related to an increase in BMI?

Independent groups t test and a multiple regression model were performed to determine whether the means of BMI are significantly different between the alcohol consumption group and the non-alcohol consumption group (See Table 2 and 3).

Research Question 5: Is area of residence associated with alcohol consumption?

Chi-square test was performed to determine whether there is a relationship between area of residence and alcohol consumption behaviors. (See Table 3)

Research Question 6: Is area of residence related to BMI, energy intake, fat intake, leisure time physical activity, and/or nutrition knowledge?

General linear models were used to determine whether area of residence is related to BMI, energy intake, fat intake, leisure time physical activity, and nutrition knowledge. In general linear models, area of residence was the independent variable with three levels, and four dependent variables were analyzed individually (See Table 3). Tukey-Kramer HSD Tests were performed to compare all pairs.

Research Question 7: Are smoking habits associated with energy intake?

Independent group t test was performed to determine whether the mean energy intake is significantly different between smokers and non-smokers. The independent variable was smoking habits and the dependent variable was energy intake. (See Table 3)

Table 3

Definition and Measurement of Key Variables

(For Chi-Square Test and Independent Group t Test)

Variable	Definition and Measurement	Scale	Continuous
BMI (Dependent Variable)	Weight in kg / height in m^2 Data gathered from health examination	Ratio	Yes
Educational Level	Education completed 1=Primary school or no education 2=Junior high school 3=Senior high school 4=University or graduate school	Nominal	No
Residence Area	Household registered residence and actually live there 1=Western area 2=Mountainous area 3=Eastern and islands area	Nominal	No
Smoking Habits	Respondent reports 0=Non-smokers 1=Smokers	Nominal (Dichotomous)	No
Alcohol Consumption	Respondent reports 0=Non alcohol consumption 1=Alcohol consumption	Nominal (Dichotomous)	No
Energy Intake	Data from 24-h dietary recall Unit: kcal / day	Ratio	Yes
Fat Intake	Data from 24-h dietary recall Percentage of energy intake	Ratio	Yes
Nutrition Knowledge Score	Count points that respondent answered nine general diet and nutrition questions correctly	Interval	No

3.8 Strategies of Data Analysis

Data analysis strategies included three levels. First, data was screened for correction and appropriation before any further analysis. Second, descriptive statistics were performed to describe the characteristics of the participants. Third, inferential statistics were applied to infer the answers of the research questions to the population. The following paragraphs describe the detailed procedures for each analysis.

3.8.1 Screening data prior to analysis

Data was first inspected for accuracy of input using univariate descriptive statistics. All out-of-range data, usually less than five cases in each variable, were deleted because it is impossible to check the accuracy of coding process. Missing values were less than five cases for age and education and about 30 cases for smoking habits, alcohol consumption, BMI, energy intake, and fat intake out of 1,183 cases. All cases with missing values in any variables were automatically excluded in the SAS analysis process. The mean and standard deviation were checked to see whether data were plausible.

The data were then screened for outlier observations. The highest five values and the lowest values were then taken out from the BMI, energy intake, and knowledge variables. The energy expenditure variable was only taken out the highest five values. About 25% of participants reported that they did not have any leisure time physical activity. Even though those were extreme values of a distribution, they would contribute an important message in this analysis. Therefore, they were retained for analysis.

Second, distributions of continuous variables were performed for test of normality and checking for outliers. Frequency histograms, boxplots, and normal probability plots were examined. The shape of distribution, location of medians, outliers, and the skewness and kurtosis statistics were all reviewed. The distribution of BMI was close to bell shape. Exactly speaking, the distribution is a little bit positively skewed, tail to the right (skewness=0.652, kurtosis=0.404). The distribution of fat intake percent was also a little bit positively skewed (skewness=0.772, kurtosis=0.713). The distribution of energy intake was skewed, tail to the right (skewness=1.422, kurtosis=2.997). The distribution of knowledge score was negatively skewed, tail to the left (skewness=-1.244, kurtosis=1.556). The distribution of energy expenditure was skewed, tail to the right (skewness=3.825, kurtosis=19.177). (See Appendix 1)

According to the central limit theorem, the sampling distribution approaches a normal distribution when the sample size gets large. How large must be the sample size? Some textbooks say 30; others suggest 100 (Jaccard, J., Becker, M.A., 2002 and Bohrnstedt, G.W., Knoke, D., 1988). Since the sample size in this study is larger than 1,000, these variables were assumed normally distributed.

Third, correlation matrix was used to test for multicollinearity. Correlation matrix was produced in JMP (See Appendix 2). The highest correlation coefficient was 0.4125, the strength of relationship between education and nutrition knowledge. There is no risk of multicollinearity if the correlation coefficient is lower than 0.7 (Tabachnick, B.G.and Fidell, L.S., 2001). Multicollinearity would be further examined by tolerance value and variance inflation factors when performing multiple regression analysis. Further examination for testing assumptions of multiple regression would be carried out in the initial screening run, described in section 3.8.3.

3.8.2 Descriptive statistics

Frequencies and valid percents were determined for sex, educational level, area of residence, smoking habits, and alcohol consumption behaviors. Sample size, mean, range, and standard deviation were determined for age, BMI, leisure time physical activity, energy intake, fat intake, and nutrition knowledge score. Gender-specific analysis was performed as well. Also, the prevalence of overweight and obesity in this sample was determined to demonstrate gender-specific prevalence across characteristic groups.

3.8.3 Inferential statistics

Multiple regression was performed for research questions 1 to 3. Bivariate correlation was performed for question 3 as well. Independent group t test was performed for questions 4, 6, and 7. Chi-square test was performed for question 5. Also, general linear model was applied for question 6. Inferential statistics were done in SAS. However, chi-square test was performed in JMP.

Further description for the process of performing multiple regression

Residuals scatterplots obtained from the initial run of multiple regression were examined for assumptions of normality, linearity, and homoscedasticity. If residuals' scatterplots looked unusual, necessary procedures such as reducing the influence of outliers and transformation of variables was implemented. However, transformation was not preferred due to the complexity of interpreting the results. Although outliers were identified in the data screening process before analysis, the residuals scatterplots were also used as a double check on the occurrence of outliers.

Before the official analysis of multiple regression, some exploratory analyses were performed. A correlation matrix helped get a sense of the strength of the relationship between variables. Stepwise function was used in the initial run for selecting variables. Age, gender, educational level, and area of residence were selected as being able to predict BMI at an alpha level of 0.1. However, according to the exploratory analyses and literature review, the researcher decided what variables should be put in the regression model eventually. Energy intake, fat intake, smoking habits, alcohol consumption, leisure time physical activity, and nutrition knowledge were added to the predicting model in order to control for confounding factors. General linear model was used to contrast the differences of least square mean BMI between areas of residence. Hakka area, metropolitan area, class I provincial townships, and class II provincial townships were found to have no significant differences between each other. The east coast area and Peng-Hu islands area had no significant difference between each other as well. This procedure helped eliminate unnecessary groups of nominal variables, and thus reduce the number of dummy variables in multiple regression models.

3.9 Summary

Data analysis was dependent on the results from a self-reported cross-sectional survey and a health examination conducted by the NAHSIT research team in 1993~1996. Data was analyzed using the Statistical Analysis System (SAS/PC V8.2 program, SAS Institute, Cary, North Carolina.) and JMP 4 (SAS Institute Inc.).

CHAPTER 4
RESULTS OF ANALYSIS

4.1 Description of the Sample

A total of 1,182 young adults aged 19 to 44 years were in this study. In this sample, 526 participants (44.5%) were male and 626 participants (55.5%) were female (Table 4). Regarding education attainment, about a quarter of the participants had no education or primary school, one-fifth had completed junior high school, approximately one-third were high school graduates, and 16% had university or graduate school educations (Table 5). A higher proportion of female participants had no education or completed primary school, while a higher proportion of male participants completed university or graduate school (Table 10).

Table 4

Gender of the Sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	526	44.5	44.5	44.5
	Female	656	55.5	55.5	100.0
	Total	1182	100.0	100.0	

Table 5

Educational Level of the Sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary School or Lower	303	25.63	25.68	25.68
	Junior High School	255	21.57	21.61	47.29
	High School	434	36.72	36.78	84.07
	University or Higher	188	15.91	15.93	100.0
	Total	1180	99.83	100.0	
Missing		2	0.17		
Total		1182	100.0		

683 participants (58%) lived in western area, 168 (14%) lived in mountainous area, and 331 (28%) resided in eastern and islands area (Table 6). The gender distributions of residence area were similar (Table 10). Nearly 40% of the sample were smokers (Table 7), and approximately 60% had alcohol consumption behaviors (Table 8). Most smokers were male, and more than 80% of male participants had alcohol consumption behaviors. However, more than 40% of females had alcohol consumption behaviors as well (Table 10).

Table 6

Area of Residence of the Sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Western Area	683	57.78	57.78	57.78
	Mountainous Area	168	14.22	14.22	72.0
	Eastern and Islands Area	331	28.0	28.0	100.0
	Total	1182	100.0	100.0	

Table 7

Smoking Habits of the Sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Non-Smokers	716	60.58	61.99	61.99
	Smokers	439	37.14	38.01	100.0
	Total	1155	97.72	100.0	
Missing		27	2.28		
Total		1182	100.0		

Table 8

Alcohol Consumption of the Sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Non Alcohol Consumption	459	38.83	39.77	61.99
	Alcohol Consumption	695	58.80	60.23	100.0
	Total	1154	97.63	100.0	
Missing		28	2.37		
Total		1182	100.0		

Table 9

Descriptive Statistics of Continuous Variables

Variable	N	Mean	Range	Std Dev
Age	1182	33.18	25.00	7.15
BMI[a]	1140	23.13	21.00	3.65
Leisure Time Physical Activity[b]	1177	61.59	1008.00	116.73
Energy Intake[c]	1136	1923.56	6346.56	993.54
Fat Intake[d]	1136	30.08	82.05	0.42
Nutrition Knowledge Score[e]	1157	6.84	9.00	1.77

[a] BMI: weight in kg / height in m^2
[b] Unit: kcal / kg / month
[c] Unit: kcal / day
[d] Unit: % of total energy intake
[e] Unit: Points (range from 0 to 9)

Table 10

Descriptive Statistics of the Sample by Gender

	Male		Female	
	Frequency	Valid Percent	Frequency	Valid Percent
Educational Level				
Primary School or Lower	90	17.18	213	32.47
Junior High School	110	20.99	145	22.10
High School	219	41.79	215	32.77
University or Higher	105	20.04	83	12.65
Area of Residence				
Western Area	310	58.94	373	56.86
Mountainous Area	73	13.88	95	14.48
Eastern or Islands Area	143	27.19	188	28.66
Smoking Habits				
Non-Smokers	154	29.79	562	88.09
Smokers	363	70.21	76	11.91
Alcohol Consumption				
Non Alcohol Consumption	94	18.18	365	57.30
Alcohol Consumption	423	81.82	272	42.70

Table 11

Descriptive Statistics of Continuous Variables by Gender

	Male			Female		
	N	Mean	Std Dev	N	Mean	Std Dev
Age	526	33.42	7.30	656	32.99	7.03
BMI[a]	510	23.37	3.27	630	22.94	3.93
Leisure Time Physical Activity[b]	524	79.50	136.00	653	47.21	96.31
Energy Intake[c]	512	2268.86	1055.21	624	1640.23	840.64
Fat Intake[d]	512	28.13	13.35	624	31.68	14.54
Nutrition Knowledge Score[e]	518	6.84	1.73	639	6.83	1.80

[a] BMI: weight in kg / height in m^2
[b] Unit: kcal / kg / month
[c] Unit: kcal / day
[d] Unit: % / total energy intake
[e] Unit: Points (range from 0 to 9)

The mean age of the sample was 33 years old (range from 19 to 44), and the mean BMI was 23 kg/m^2. The average leisure time physical activity level was about 62 kcal per kg body weight per month. Males had much higher physical activity level than that of females. The average energy intake of males was nearly 2,270 kcal and 1,640 kcal of females. The mean fat intake was 28% for men and 32% for women. The mean nutrition knowledge score was 6.8 points out of 9 points for both men and women (Table 9 and 11).

The prevalence of overweight and obesity was nearly 40% for all participants. The prevalence decreased with increasing education attainment. The prevalence of obesity was approximately 40% in mountainous area, which was much higher than for the other areas. There were no obvious differences in overweight and obesity prevalence whether participants smoked or drank. (See Table 12)

Table 12

Overweight and Obesity Prevalence in Young Adults[a] in Taiwan by Gender

	Normal Weight (18.5≦BMI<24)			Overweight (24≦BMI<27)			Obesity (BMI≧27)		
Unit: %	M	F	All	M	F	All	M	F	All
All Participants	59.29	62.59	61.07	25.47	22.34	23.78	15.24	15.07	15.15
Educational Level									
Primary School or Lower	52.33	44.67	47.00	31.40	30.46	30.74	16.28	24.87	22.26
Junior High School	50.51	59.52	55.56	28.28	30.16	29.33	21.21	10.32	15.11
High School	62.94	73.86	68.10	22.34	13.64	18.23	14.72	12.50	13.67
University or Higher	67.37	92.31	77.50	24.21	6.15	16.88	8.42	1.54	**5.63**
Area of Residence									
Western Area	65.47	73.89	69.93	25.18	18.79	21.79	9.35	7.32	8.28
Mountainous Area	30.00	32.58	31.45	37.14	23.60	29.56	32.86	43.82	**38.99**
Eastern or Islands Area	61.83	57.14	59.25	19.85	28.57	24.66	18.32	14.29	16.10
Smoking Habits									
Non-Smokers	61.70	62.91	62.64	26.95	22.75	23.69	11.35	14.34	13.67
Smokers	57.88	60.66	58.31	15.15	19.67	24.30	16.97	19.67	17.39
Alcohol Consumption									
Non Alcohol Consumption	56.63	65.71	63.80	25.30	22.76	23.29	18.07	11.54	12.91
Alcohol Consumption	59.28	58.90	59.13	26.03	21.61	24.36	14.69	19.49	16.51

[a] Age=19~44

4.2 Analysis Results of Research Questions

4.2.1 Research Question 1

Research question one studied what explanatory variables can predict BMI using a multiple regression model. A residuals scatterplot of predicted values of BMI indicated that the assumptions of normality, linearity, and homoscedasticity were met. The residuals scatterplot revealed a pileup of residuals in the center of the plot at each value of predicted score, and a normal distribution of residuals trailed off symmetrically from the center. Furthermore, the tolerance values ($1-R^2$) of each variable were between 0.43376 and 0.93544, and the variance inflation values (the reciprocal of tolerance) were between 1.069 and 2.305. The tolerance and variance inflation values of each variable showed this analysis had no risk of multicollinearity.

Twelve variables, shown in Table 13, were in the multiple regression model and the total of 1,074 cases were analyzed. The analysis results indicated that this model significantly predicted BMI (P value < 0.0001, R^2=0.2102) at an alpha level of .05. Age and area of residence was positively related to increased BMI, while educational level was negatively related to higher BMI. Age, senior high school or higher education, mountainous area, and eastern and islands area contributed 21% of variance in BMI in this sample. A regression equation obtained from this analysis was as followed:

BMI=19.5 + 0.113 Age - 0.369 Female - 1.373 Senior high school and higher education - 0.423 Junior high school + 3.143 Mountainous area + 0.586

Eastern islands area + 0.197 Smoking + 0.321 Alcohol consumption - 0.0004 Leisure time physical activity + 0.0001 Energy intake - 0.003 Fat intake percent - 0.014 Nutrition knowledge

This model has been compared with a simplified model, encompassing only those variables that were found to be statistically significant at an alpha level of .05. Both results were similar (Table 13 and Table 14).

For all participants, an increase in one year of age was associated with an average increase in BMI of 0.113 kg/m^2, controlling for all other variables. When using primary school education as a reference, an increase of educational level to senior high school or higher was associated with an average decrease in BMI of 1.373 kg/m^2, controlling for all other variables. As to area of residence, using the western area as a reference and holding all other variables constant, mountainous area residence and eastern islands area residence were associated with an average increase in BMI of 3.143 kg/m^2 and 0.586 kg/m^2, respectively. All other variables contributed little to this predicting model and had no statistically significant influence in BMI at an alpha level of .05 (Table 13).

Table 13

Multiple Regression Model Predicting BMI for Young Adults in Taiwan

Variable	Parameter Estimate	Standard Error	P-Value
<u>All Participants</u> (n=1074)			
Intercept	19.500	0.807	0.0001
Age	0.113	0.016	0.0001
Female[a]	-0.369	0.273	0.18
Senior High School and Higher[b]	-1.373	0.304	0.0001
Junior High School[b]	-0.423	0.323	0.19
Mountainous Area[c]	3.143	0.316	0.0001
Eastern and Islands Area[c]	0.586	0.237	0.01
Smoking[d]	0.197	0.263	0.45
Alcohol Consumption[e]	0.321	0.231	0.17
Leisure Time Physical Activity	-0.0004	0.0009	0.70
Energy Intake	0.0001	0.0001	0.32
Fat Intake Percent	-0.003	0.008	0.74
Nutrition Knowledge Score	-0.014	0.068	0.84

R-square=0.2102 Adjust R-square=0.2013
[a] Reference: Male, [b] Reference: Primary school, [c] Reference: Western area,
[d] Reference: Non-smoking, [e] Reference: Non alcohol consumption

Table 14

Multiple Regression Model Predicting BMI for Young Adults in Taiwan (A Simplified Model)

Variable	Parameter Estimate	Standard Error	P-Value
<u>All Participants</u> (n=1140)			
Intercept	19.283	0.606	0.0001
Age	0.116	0.015	0.0001
Senior High School and Higher[b]	-1.178	0.256	0.0001
Junior High School[b]	-0.282	0.299	0.34
Mountainous Area[c]	3.335	0.292	0.0001
Eastern and Islands Area[c]	0.688	0.225	0.002

R-square=0.2042 Adjust R-square=0.2007
[b] Reference: Primary school, [c] Reference: Western area,

4.2.2 Research Question 2

Research question two followed the first question and studied whether the BMI predicting model varied by gender. Two multiple regression models were performed separately for male and female. Residual scatterplots of predicted values of BMI for each model indicated that the assumptions of normality, linearity, and homoscedasticity were met. The tolerance and variance inflation values of each variable showed this analysis had no risk of multicollinearity.

Analysis for men:

Eleven variables, shown in Table 15, were in the multiple regression model and the total of 488 cases were analyzed. The analysis results indicated that this model significantly predicted BMI (P value < 0.0001, R^2=0.1495) at an alpha level of .05. Age and mountainous area residence were positively related to increased BMI (P value < 0.0001). Smoking habits were positively related to higher BMI (P value = 0.0803) at an alpha level of 0.1. These explanatory variables contributed 15% of variance in BMI in this sample, mainly by age, mountainous area, and smoking habits. A regression equation obtained from this analysis was as followed:

BMI=18.142 + 0.102 Age – 0.095 Senior high school and higher education - 0.704 Junior high school + 2.560 Mountainous area + 0.513 Eastern islands area + 0.541 Smoking - 0.187 Alcohol consumption - 0.0009 Leisure time physical activity + 0.0001 Energy intake - 0.001 Fat intake percent - 0.105

Nutrition knowledge

In men, an increase in one year of age was associated with an average increase in BMI of 0.102 kg/m^2, controlling for all other variables. Using the western area as a reference, mountainous area residence was associated with an average increase in BMI of 2.560 kg/m^2, holding all other variables constant. All other variables contributed little to this predicting model and had no statistically significant association with BMI at an alpha level of .05.

Table 15

Multiple Regression Model Predicting BMI for Male Young Adults in Taiwan

Variable	Parameter Estimate	Standard Error	P-Value
Male (n=488)			
Intercept	18.142	1.049	0.0001
Age	0.102	0.021	0.0001
Senior High School and Higher[b]	-0.095	0.442	0.83
Junior High School[b]	0.704	0.488	0.15
Mountainous Area[c]	2.560	0.442	0.0001
Eastern and Islands Area[c]	0.513	0.328	0.12
Smoking[d]	0.541	0.309	0.08
Alcohol Consumption[e]	-0.187	0.365	0.61
Leisure Time Physical Activity	0.0009	0.001	0.41
Energy Intake	0.0001	0.0001	0.41
Fat Intake Percent	-0.001	0.012	0.91
Nutrition Knowledge Score	0.105	0.094	0.27

R-square=0.1496   Adjust R-square=0.1299

[b] Reference: Primary school, [c] Reference: Western area, [d] Reference: Non-smoking,
[e] Reference: Non alcohol consumption

Analysis for women:

A total of 586 cases were analyzed in a multiple regression model with BMI as the dependent variable and eleven predicting variables, shown in Table 16. The analysis results indicated that this model significantly predicted BMI (P value < 0.0001, R^2=0.2825) at an alpha level of .05. Age and mountainous area residence were positively related to increased BMI (P value < 0.0001), while senior high school or higher education was negatively related to higher BMI (P value < 0.0001). At an alpha level of 0.1, junior high school education was negatively associated with increased BMI (P value = 0.0542) and alcohol consumption was positively related to increased BMI (P value = 0.0820). These explanatory variables contributed as much as 28% of variance in BMI in this sample, primarily by age, educational level, mountainous area residence, and alcohol consumption. A regression equation produced by this analysis was as followed:

BMI=19.986 + 0.122 Age – 2.017 Senior high school and higher education - 0.801 Junior high school + 3.563 Mountainous area + 0.469 Eastern islands area - 0.336 Smoking - 0.533 Alcohol consumption - 0.001 Leisure time physical activity + 0.0001 Energy intake - 0.003 Fat intake percent - 0.121 Nutrition knowledge

In women, an increase in one year of age was associated with an average increase in BMI of 0.122 kg/m^2, controlling for all other variables. When using primary school education as a reference, an increase of educational level to senior high school or higher education was associated with an average decrease in BMI of 2.017 kg/m^2, holding all other variables constant. If using the western area as a reference, mountainous area residence was associated with an average increase in BMI of 3.563 kg/m^2, controlling for all other variables. All variables other than age, senior high school education, and mountainous area residence contributed little to this predicting model and had no statistically significant association with BMI at an alpha level of .05.

Table 16

Multiple Regression Model Predicting BMI for Female Young Adults in Taiwan

Variable	Parameter Estimate	Standard Error	P-Value
Female (n=586)			
Intercept	19.986	1.120	0.0001
Age	0.122	0.023	0.0001
Senior High School and Higher[b]	-2.017	0.416	0.0001
Junior High School[b]	-0.831	0.431	0.05
Mountainous Area[c]	3.563	0.446	0.0001
Eastern and Islands Area[c]	0.469	0.335	0.16
Smoking[d]	-0.336	0.460	0.47
Alcohol Consumption[e]	0.533	0.306	0.08
Leisure Time Physical Activity	-0.001	0.002	0.33
Energy Intake	0.0001	0.0002	0.61
Fat Intake Percent	-0.003	0.011	0.78
Nutrition Knowledge Score	-0.121	0.097	0.21

R-square=0.2825 Adjust R-square=0.2687

[b] Reference: Primary school, [c] Reference: Western area, [d] Reference: Non-smoking,

[e] Reference: Non alcohol consumption

4.2.3 Research Question 3

Research question three studied whether the BMI increase with age using a bivariate correlation analysis and a multiple regression model. A residual scatterplot of predicted values of BMI produced by multiple regression analysis indicated that the assumptions of normality, linearity, and homoscedasticity were met. The tolerance and variance inflation values of each variable showed this analysis had no risk of multicollinearity.

A bivariate correlation analysis:

A result of a bivariate correlation analysis with a total of 1,140 cases analyzed showed that age was significantly related to BMI (P value < 0.0001, $R^2 = 0.0745$). Age alone explained about 7% of variance in BMI in this sample. A simple regression equation produced by this analysis was as followed:

$$BMI = 18.493 + 0.140\ Age$$

There was a linear relationship between age and BMI in this sample. An increase in ten years of age was associated with an average increase in BMI of 1.4 kg/m^2. (See Table 17)

Table 17

Bivariate Correlation between Age and BMI for Young Adults in Taiwan

Variable	Parameter Estimate	Standard Error	P-Value
All Participants (n=1140)			
Intercept	18.493	0.496	0.0001**
Age	0.140	0.015	0.0001**

R-square=0.0745 Adjust R-square=0.0737
** P value <.0001

A multiple regression analysis:

In a multiple regression model, BMI was the dependent variable, and age was the explanatory variable. Sex, educational level, area of residence, leisure time physical activity, smoking habits, alcohol consumption, energy intake, fat intake, and nutrition knowledge were added to the model as controlling variables. The total of 1,074 cases were analyzed and the result indicated that this model significantly predicted BMI (P value < 0.0001, R^2=0.2102) at an alpha level of .05. (See Table 13) A regression equation produced from this analysis was as followed:

BMI=19.5 + 0.113 Age - 0.369 Female - 1.373 Senior high school and higher education - 0.423 Junior high school + 3.143 Mountainous area + 0.586 Eastern islands area + 0.197 Smoking + 0.321 Alcohol consumption - 0.0004 Leisure time physical activity + 0.0001 Energy intake - 0.003 Fat intake percent - 0.014 Nutrition knowledge

Age was positively related to increased BMI in this model (P values < 0.0001). An increase in ten years of age was associated with an average increase in BMI of 1.13 kg/m^2, controlling for sex, educational level, area of residence, physical activity, energy intake, fat intake, and nutrition knowledge. Age together with all these controlling variables had a linear relationship with BMI and explained 21% of variance in this multiple regression analysis.

4.2.4 Research Question 4

Research question four studied whether participants with alcohol consumption behaviors have higher BMI. An independent group t test compared the mean BMI for participants without alcohol consumption behaviors (M = 22.787, SD =3.6368) with that for participants with alcohol consumption behaviors (M = 23.386, SD = 3.6639). This test was found to be statistically significant at an alpha level of .05, t (1112) = -2.60, $p < 0.01$, indicating that participants without alcohol consumption behaviors had lower mean BMI than that of participants with alcohol consumption behaviors. The strength of the relationship between BMI and alcohol consumption, as indexed by eta^2, was 0.006. The 95% confidence interval for the mean difference was –1.02 to –0.143. (See Table 18)

Table 18

Independent Group t Test for the Relationship between Alcohol Consumption and BMI

Variable	Alcohol Consumption	N	Lower CL Mean	Mean	Upper CL Mean	Std Dev
BMI	No	444	22.448	22.787	23.127	3.6368
BMI	Yes	670	23.090	23.368	23.646	3.6639
BMI	Diff (No-Yes)		-1.020	-0.581	-0.143	3.6531

Df = 1112, t value = -2.60, P = 0.0095

In multiple regression models, alcohol consumption was not found to be statistically significant at an alpha level of .05, controlling for age, dietary factors, lifestyle factors, and environmental factors (Table 13, 15 and 16). In female participants, alcohol consumption was found to be able to predict BMI at an alpha level of .1 (Table 16). Compared to non-alcohol consumption, alcohol consumption was associated to an average increase in BMI of 0.533 kg/m^2, controlling for all other variables.

4.2.5 Research Question 5

Research question five studied whether there is a relationship between area of residence and alcohol consumption.

Chi-square test for all participants:

A chi-square test was applied to the relationship between area of residence and alcohol consumption and found to be statistically significant at an alpha level of .05, χ^2 (2, N=1154) = 13.450, p = 0.0012. The observed frequencies for the six cells could be found in Table 19. The R-square statistics, the strength of the relationship, was 0.0064. This indicates that the strength of the relationship was weak, although the test result was statistically significant. The cell chi-square values, $(O-E)^2 / E$, for participants who lived in mountainous area (6.9098 and 4.5635) were relatively large, meaning that these two cells contributed more to the significant result. Examination of the deviation (observed minus expected frequencies) suggested that participants who lived in the mountainous area were more likely to have alcohol consumption behaviors.

Table 19

Contingency Table of Residence Area by Alcohol Consumption for All Participants

Count Total% Column% Row% Expected Cell Chi^2	Western Area	Mountainous Area	Eastern and Islands Area	Total
Non Alcohol Consumption	**278** 24.09 41.74 60.57 264.899 0.6479	**45** 3.90 26.95 9.80 66.4237 **6.9098**	**136** 11.79 42.37 29.63 127.677 0.5426	459 39.77
Alcohol Consumption	**388** 33.62 58.26 55.83 401.101 0.4279	**122** 10.57 73.05 17.55 100.576 **4.5635**	**185** 16.03 57.63 26.62 193.323 0.3583	695 60.23
Total	666 57.71	167 14.47	321 27.82	1154

Gender-specific chi-square tests:

Chi-square tests were also applied to the relationship between area of residence and alcohol consumption for each gender. In men, the test was found to be not statistically significant at an alpha level of .05, χ^2 (2, $\underline{N}$=517) = 0.378, $\underline{p}$ = 0.8278. The observed frequencies for the six cells could be found in Table 20. In women, the test was found to be statistically significant at an alpha level of .05, χ^2 (2, $\underline{N}$=637) = 29.046, $\underline{p} < 0.0001$. The observed frequencies for the six cells could be found in Table 21.The R-square statistics, the strength of the relationship, was 0.0236. Thus the strength of the relationship was quite weak, although the test result was statistically significant. The cell chi-square values, $(O-E)^2 / E$, for participants who lived in mountainous area (14.1857 and 10.5713) were relatively large, meaning that these two cells contributed more to the significant result. Examination of the deviation (observed minus expected frequencies) suggested that female participants who lived in the mountainous area were more likely to have alcohol consumption behaviors than their counterparts living in other areas.

Table 20

Contingency Table of Residence Area by Alcohol Consumption for Men

Count Total% Column% Row% Expected Cell Chi^2	Western Area	Mountainous Area	Eastern and Islands Area	Total
Non Alcohol Consumption	**55** 10.64 18.09 58.51 55.2727 0.0013	**15** 2.90 20.55 15.96 13.2727 0.2248	**24** 4.64 17.14 25.53 25.4545 0.0831	94 18.18
Alcohol Consumption	**249** 48.16 81.91 58.87 248.727 0.0003	**58** 11.22 79.45 13.71 59.7273 0.0500	**116** 22.44 82.86 27.42 114.545 0.0185	423 81.82
Total	304 58.80	73 14.12	140 27.08	517

Table 21

Contingency Table of Residence Area by Alcohol Consumption for Women

Count Total% Column% Row% Expected Cell Chi^2	Western Area	Mountainous Area	Eastern and Islands Area	Total
Non Alcohol Consumption	**223** 35.01 61.60 61.10 207.425 1.1694	**30** 4.71 31.91 8.22 53.8619 **10.5713**	**112** 17.58 61.88 30.68 103.713 0.6622	365 57.30
Alcohol Consumption	**139** 21.82 38.40 51.10 154.575 1.5693	**64** 10.05 68.09 23.53 40.1381 **14.1857**	**69** 10.83 38.12 25.37 77.2873 0.8886	272 42.70
Total	362 56.83	94 14.76	181 28.41	637

4.2.6 Research Question 6

Research question six studied whether area of residence was related to BMI, energy intake, fat intake, leisure time physical activity, and nutrition knowledge. Five general linear models were performed separately for five dependent variables. The results suggested that all dependent variables were significantly different between three residence areas except mean fat intake at an alpha level of .05 (Table 22). However, when comparing the least square mean of BMI, energy intake, fat intake, leisure time physical activity, and nutrition knowledge score between three residence areas, there were no significant differences in least square mean of energy intake and fat intake between three residence areas (Table 23). The results also suggested that mountainous area had significantly higher BMI and leisure time physical activity but had significantly lower nutrition knowledge score than other areas, at an alpha level of .05.

Table 22

Results of GLM Procedures: Relationship between Area of Residence and BMI, Energy Intake, Fat Intake, Leisure Time Physical Activity, and Nutrition Knowledge Score

Dependent Variable	Type III SS	Mean Square	F Value	P Value
BMI	383.15	191.57	17.10	< 0.0001
Energy Intake	10599834.95	5299917.47	5.49	0.0042
Fat Intake	47.23	23.62	0.12	0.8882
Physical Activity	163720.87	81860.43	6.21	0.0021
Nutrition Knowledge Score	63.56	31.78	14.00	< 0.0001

Independent Variable: Area of residence

Table 23

Comparisons of Least Square Mean of BMI, Energy Intake, Fat Intake, Leisure Time Physical Activity, and Nutrition Knowledge by Area of Residence

Area of Residence	BMI[1]	Energy Intake[2]	Fat Intake[3]	Physical Activity[4]	Nutrition Knowledge Score[5]
Western Area	22.49[ac]	1853.44	30.15	47.27[df]	7.16[gi]
Mountainous Area	24.97[ab]	1975.84	29.36	83.20[de]	6.28[gh]
Eastern and Islands Area	23.18[bc]	2093.31	30.34	71.80[ef]	6.77[hi]

Note: LSMeam with same superscripts were significantly different, $p<0.05$

[1] Unit: kg/m^2 [2] Unit: kcal/day [3] Unit: % of total kcal per day [4]Unit: kcal/kg/month

[5] Unit: points (range from 0 to 9)

4.2.7 Research Question 7

Research question seven studied the relationship between smoking habits and energy intake. An independent group t test compared the mean energy intake for non-smokers (M = 1734.2, SD =905.94) with that of smokers (M = 2250.9, SD = 1052.3). This test was found to be statistically significant at an alpha level of .05, $t(804) = -8.39$, $p < 0.0001$, indicating that non-smokers had lower energy intake than that of smokers. The strength of the relationship between smoking habits and energy intake, as indexed by eta^2, was 0.08. The 95% confidence interval for the mean difference was –633.5 to –399.9. (See Table 24)

Table 24

Independent Group t Test for the Relationship between Smoking Habits and Energy Intake

Variable	Smoking Habits	N	Lower CL Mean	Mean	Upper CL Mean	Std Dev
Eng. Intake	Non-Smokers	683	1666.1	1734.2	1802.2	905.94
Eng. Intake	Smokers	427	2150.8	2250.9	2351.0	1052.3
Eng. Intake	Diff (No-Yes)		-633.5	-516.7	-399.9	964.86

Df = 804, t value = -8.39, P < 0.0001

General linear models were also performed to determine the relationship between smoking habits and energy intake by gender. The relationship between smoking habits and energy intake was statistically significant in both men and women at an alpha level of 0.05. (See Table 25)

Table 25

General Linear Models for the Relationship between Smoking Habits and Energy Intake

Participants	Type III SS	Mean Square	F Value	P Value
All	70144918.02	70144918.02	75.35	< 0.0001
Men	4551044.70	4551044.70	4.09	0.0437
Women	2810563.57	2810563.57	3.97	0.0467

ID: Smoking habits, DV: Energy intake

Table 26

Least Square Mean of Energy Intake by Smoking Habits

	All Participants	Men	Women
Non-Smokers	1734.17	2131.08	1622.47
Smokers	2250.87	2339.00	1830.45

CHAPTER 5
DISCUSSION

This study aims to explore risk factors that were associated with BMI among young adults in Taiwan, considering biological factors, dietary factors, environmental factors, and lifestyle factors simultaneously. Results of each research question are discussed below:

5.1 Research Question 1 and 2 – Predictors of BMI

Age, educational level, and area of residence were able to predict BMI in a multiple regression model at an alpha level of .05. The relationship between BMI, age, educational level, and area of residence was found to vary by gender. Age, educational level, and area of residence accounted for 21% of variance in all participants, 15% in men, and 28% in women in this sample. Smoking habits was able to significantly predict BMI in men, and alcohol consumption was able to significantly predict BMI in women at an alpha level of 0.1. Other factors, including energy intake, fat intake, leisure time physical activity, and nutrition knowledge score, failed to predict BMI in this model.

Age and area of residence had a consistent direct relationship with increased BMI in all participants, men, and women. Educational level, on the other hand, revealed inconsistent results in different analyses. There was an inverse relationship between educational level and BMI in all participants and women. However, there was no significant association between educational level and BMI in men. Using educational level as an indicator of socioeconomic status, this inconsistent relationship between socioeconomic status and obesity in men and women was also typically found in studies of BMI in developed countries (Sobal J. and Stunkard, A.J., 1989, Dryson, E. et al., 1992 and Molarius, A. et al., 2000). With a GNP of USD $13,000, Taiwan could be considered a developed country. This analysis result supports the earlier studies and is not surprising.

Area of Residence and BMI

Among three predictors of BMI in this study, area of residence was a very strong predictor for this population. Using the western area as a reference, mountainous area residents had a high risk of increasing their BMI as much as 3.143 kg/m^2 on average, controlling for age, socioeconomic status, dietary factors, and lifestyle factors. In women, the regression coefficient was even higher, 3.563. This huge number manifests a tremendous discrepancy between western area and mountainous area. This suggests that the mountainous area of Taiwan should be given priority in working toward controlling people's body weight. The mountainous area represents the most rural area in Taiwan and is isolated from the vast plain by central mountains of Taiwan Island. This result also supports the idea that higher obesity prevalence often occurs in more rural areas in developed countries (Ramsey, P.W. et al., 2002, Berg, I.M. et al., 2001 and Reeder, B.A. et al., 1997), while inversely higher prevalence of overweight and obesity occurs in urban areas in developing countries (International Diabetes Institute, 2000, Paeratakul, S. et al., 1998 and Popkin, B.M. et al., 1995). The eastern and islands area had an average increase in BMI of 0.586 kg/m^2 compared to the western area in all participants, but this relationship was not statistically significant in gender-specific analysis.

Educational Level and BMI

Educational level was the second strongest predictor of BMI in this regression model. Participants with a senior high school education or higher had an average decrease in BMI of 1.373 kg/m^2 in all participants and 2.017 kg/m^2 in women compared to participants with only primary school education or no education. There was no difference in BMI between junior high school education and primary school education or no education. In an exploratory analysis of multiple regression, senior high school education and university or graduate education had very close coefficients (-1.3658 and –1.2924), therefore, these two dummy variables were coded together in final analysis. This result implied that a senior high school education or higher would provide a protection by decreasing in BMI of 1.373 kg/m^2 on average, or even 2.017 kg/m^2 in women, when controlling for age, area of residence, dietary factors, and lifestyle factors. The magnitude of educational effect on BMI found in this study was similar to Paeratakul et al., 1998 a Chinese study.

Insignificant Factors and BMI

Dietary factors and physical activity were recognized as keys in rising or falling body weight. Surprisingly, they were not striking predictors in this model. Popkin and Paeratakul reported a significantly positive relationship between energy intake, fat intake, and BMI in a Chinese population (Paeratakul, S. et al., 1998 and Popkin, B.M. et al., 1995). They believed that some studies failed to find a positive relationship between diet and obesity might result from the weakness in study design, methodological flaws, confounding factors of extraneous factors, narrow range of dietary intakes, and the measurement error in the dietary data. Comparing the NAHSIT with the national survey in China, one clear difference is in the measuring method for dietary intake. In the NAHSIT, one 24-hour dietary recall was administered along with food frequency questionnaire to evaluate participants' dietary intake. However, the national survey in China applied three consecutive 24-hour dietary recalls and compared the individual records with household intake inventory. This protocol could reduce the random fluctuation in day-to-day intake and improve the accuracy of response. Therefore, measurement issues could be a reason for failing to find a significant result in this current study.

Another explanation might be the relatively weak association between dietary factors and BMI when competed with other factors in the regression model. Educational level and area of residence might have certain impact on dietary intake. However, it requires further study in order to verify this.

Measurement issues regarding physical activity were another concern in this study. Most studies used three to five categories to identify the different levels of physical activity in collecting the data (Paeratakul, S. et al., 1998, Artalejo, F.F. et al., 2002). Some studies classified the individual's occupation according to physical activity levels (Marins, V.M. et al., 2001, Artalejo, F.F. et al., 2002 and Dryson, E. et al, 1992). In the NAHSIT, relatively detailed information regarding leisure time physical activity was collected, including the type, frequency, and time of physical activity. This could be an advantage of gathering accurate data under the assumption of participants could correctly estimate their physical activity in the past month before being interviewed. However, if individuals failed to do so, this method could introduce more bias into the study. Moreover, even if the reported data were correct, the information collected regarding the type of exercise was insufficient to determine its intensity. According to the Compendium of Physical Activities (Ainsworth, B.E. et al., 1993), the intensity of each type of exercise could be very different. Due to inadequate information, general intensity was adopted for each type of exercise when constructing the composite variable of leisure time physical activity in this study.

5.2 Research Question 3 – Relationship between Age and BMI

The direct relationship between age and BMI was consistent in the literature, thus this finding was not surprising here (Popkin, B.M. et al., 1995, Paeratakul, S. et al., 1998, Reddy, B.N., 1998, Marins, V.M. et al., 2001 and

Artalejo, F.R. et al., 2002). In this study, an increase in ten years of age led to an average increase in BMI of 1.13 kg/m^2 in all participants, controlling for dietary factors, socioeconomic status, and lifestyle factors. In a China study, however, an increase in ten years of age only increased in BMI of 0.51 kg/m^2 on average (Paeratakul, S. et al., 1998). The magnitude of age effect on BMI might vary by populations and predicting models. A bivariate analysis of this study showed that an increase in ten years of age was correlated to an average increase in BMI of 1.4 kg/m^2. Age alone explained about 7% of variance in BMI in this sample without controlling for other factors. When considering sex, dietary factors, socioeconomic status, area of residence, and lifestyle factors, the magnitude of age effect on BMI decreased 0.27 kg/m^2. This means the age-BMI relationship was confounded by some of those factors. Additionally, age was found to have a linear relationship with BMI in this study. However, Reddy B.N. (1998) suggested that age-BMI was a non-linear relationship because BMI started declining at age of 50 to 60. However, due to the narrow age range of this study, the non-linear relationship of age would not be evident.

5.3 Research Question 4 and 5 – Area of Residence and Alcohol Consumption

Area of residence had a significant association with alcohol consumption behaviors based on a chi-square test. The mountainous area was found to have a higher proportion of observed cases with alcohol consumption behaviors than expected. This relationship was not statistically significant in men. This might be due to the higher proportion of men with alcohol consumption behaviors in every area (about 80%). However, the relationship was stronger in women. In the mountainous area, 68% of women had alcohol consumption behaviors, while only 38% of women in other areas had alcohol consumption behaviors. Fan, T.S. et al. also reported that 50.2% of aborigines had alcohol consumption behaviors: 41.2% drank more than 200 c.c. daily; 30.4% drank for 6-10 years, and nearly 40% drank for more than 10 years. Rice wine (22% alcohol) and beer (3.5-5% alcohol) were the common alcohol sources.

Based on Fan's report, I estimated that the possible excess daily energy intake from alcohol by assuming a person consumed 100 c.c. of rice wine and 100 c.c. of beer would be 180 kcal per day, about 5,040 kcal per month. The excess energy intake could increase body weight by 0.65 kg per month, without considering alcohol's adverse health effect. In addition, an independent group t test indicated that alcohol consumption behaviors were significantly related to BMI in this study. Participants with alcohol consumption behaviors had higher BMI than their counterparts. However, this relationship might be confounded by other factors, as alcohol consumption was not found to be statistically significant at an alpha level of .05 in the multiple regression model. In the multiple regression model, alcohol consumption was found to be statistically significant at an alpha level of .1 in women, but not in men. Therefore, whether alcohol consumption is an attribute of causing overweight and obesity in mountainous area needs further study.

5.4 Research Question 6 – Relationship between Area of Residence and other Variables

The prevalence of obesity (BMI≧27) was 38.99 % in the mountainous area. This astonishing number was nearly five times that of the western area and more than two times that of the eastern and islands area in Taiwan. For this reason, some special analyses were done to explore the differences between three areas in Taiwan.

In general linear models, area of residence was significantly related to BMI, energy intake, physical activity, and nutrition knowledge score. However, the mean energy intake and fat intake were not found to be significantly different between three areas. In contrast, physical activity level and nutrition knowledge score were significantly different in each pair of the residence area. The mountainous area was found to have the highest physical activity level and have the lowest nutrition knowledge score among three residence areas. Physical activity level usually has an inverse relationship with increased BMI. However, the mountainous area had both the highest BMI and physical activity level among three areas. This could be explained by the ratio of fat to muscle in the mountainous area. The anthropometric data of the NAHSIT showed that the mountainous area had a higher proportion of participants whose body fat percent exceeded the standard than that of other areas, particularly in women (Kao, M.D. et al, 1998). This suggests that the higher BMI of mountainous area residents was attributed to body fat.

The nutrition knowledge score was found to have a significantly positive relationship with educational level but not dietary intake. No obvious connection between nutritional knowledge score and obesity was found in this study. However, the lowest diet and nutrition knowledge score in the mountainous area might contribute to their adverse health behaviors and outcomes. Most residents in the mountainous area are aborigines of Taiwan. Taiwanese Aborigines were reported to have many adverse health behaviors such as tobacco use, alcohol consumption, and betel nuts chewing (Li, Y.M. and Chang, T.K, 1999). Life expectancy of aborigines was 59.4 years in men and 69.4 years in women, ten years less than the other Taiwanese on average (Fan, T.S., Li, Y.C. et al., 2001).

Participants in the mountainous area had the enormous prevalence of obesity yet had the highest physical activity level compared to other areas. Also, their energy intake and fat intake were similar to that of other areas. While other factors such as ethnic differences may cause this contradictory finding, the accuracy of dietary records in the mountainous area is suspect for two reasons. First, from the food frequency questionnaire data of the NAHSIT, the mountainous area had the highest frequency of consuming high fat foods (Tzeng, M.S. et al., 1999). This result was inconsistent with my analysis from the 24-hour dietary recall data. Second, low consumption levels in overweight and obesity individuals were common due to their tendency to under-report or to their frequent dieting conditions (Marins, V.M. et al., 2001 and Pryer, J.A., 1997). Thus, the self-reported dietary data may be underestimated for the mountainous area. Further studies are needed to explore the relationship between dietary intake and BMI in the mountainous area, taking into account biological factors, environmental factors, and lifestyle factors.

People living in rural areas usually have fewer educational and economic opportunities, less access to health care and sanitary facilities, and greater transportation problems than do people living in urban areas (Felton, G.M. et al., 2002 and Fan, T.S. et al., 2001) In addition to the above problems, unique social and cultural customs and lifestyles may also contribute to the discrepancies of health status between the aborigines and other Taiwanese (Fan, T.S. et al., 2001). The prevalence of overweight and obesity was double in the mountainous area than other areas. Highest physical activity level, lowest diet and nutrition knowledge score, relatively low educational level, and higher alcohol consumption rate in women were identified as the characteristics of the mountainous area. Age, educational level, and area of residence were found to be able to predict BMI in the current study. However, it is unclear that how these factors influence the obesity prevalence in the mountainous area. It should be a priority to further study these questions. If the environmental factors are not improved and the obesity prevalence continues to increase in the mountainous area, the problems of social inequality in health could be worsened in Taiwan.

5.5 Research Question 7 – Smoking Habits and Energy Intake

Smoking habits were not a significant predictor of BMI in the multiple regression model. In men, it was significantly related to BMI at an alpha level Of .1. An independent group t test showed the significant relationship between smoking habits and energy intake. However, this association was confounded by gender. For example, seventy percent of men had smoking habits, while only 12% of women were smokers. Also, men had higher daily energy intake (mean = 2,269) than that of women (mean = 1,640). Gender-specific analysis showed a significant relationship (P=0.0437 and 0.0467) between smoking habits and energy intake at an alpha level of .05. However, the differences of energy intake between smokers and non-smokers shrank in gender-specific analysis, indicating that smokers had slightly higher energy intake than that of non-smokers in both men and women.

5.6 Other Issues

Income, educational level, and occupation are common indicators of socioeconomic status. In this study, educational level was the only indicator of socioeconomic status. This single variable was not sufficient to statistically evaluate the SES impact on obesity. It is known that fewer economic opportunities are available in the mountainous area and most young people have moved out this area because of few employment opportunities. Income level could have an impact on obesity in this area. Due to this, SES should be examined in future studies.

Additionally, this study was based on cross-sectional data. Some factors such as dietary intake and physical activity vary over time, and thus could not be comprehensively analyzed here. A future study could benefit from longitudinal comparisons.

5.7 Limitations to this Study

There are three limitations to this study. First, the age range in this study was limited to adults aged 19 to 44 years, and therefore the results are not generalizable to the overall Taiwanese population. Second, income level was not a variable in this study because the income information was not available in the survey dataset. Consequently, the economic influence on obesity in young Taiwanese adults cannot be analyzed in this study. Third, dietary intake was based on 24 hours recall and physical activity was based on self-reported data, so both variables could be under- or overestimated.

CHAPTER 6
CONCLUSION

6.1 Conclusions

A summary of this study is displayed in Table 27. Age, educational level, and area of residence can predict BMI in young adults in Taiwan, controlling for lifestyle factors. An increase in ten years of age was associated with an average increase in BMI of 1.13 kg/m^2 in all participants, controlling for other variables. Compared to primary school education or no education, a senior high school education or higher could provide protection for decreasing in BMI of 1.373 kg/m^2 in all participants and 2.017 kg/m^2 in women on average, controlling for other variables. Area of residence was found to be a very strong predictor of BMI in this population. Compared to the western area, the mountainous area residents had a high risk of increasing their BMI of 3.143 kg/m^2 in all participants and 3.563 kg/m^2 in women on average, holding other variables constant. Age, educational level, and area of residence accounted for 21% of variance in BMI in all participants, and 28% of variance in women in this population. However, this model could not explain more than two-thirds of variance in BMI. Further studies are needed to find a better predicting model of BMI.

The prevalence of obesity was 38.99% in the mountainous area at the age of 19 to 44. If included those who were overweight, it accounted for almost

70% of residents in the mountainous area. It was found that senior high school education was a strong predictor of BMI, particularly in women. On average, the mountainous area had lower educational level than other areas. One recommendation from this study is to develop a comprehensive plan to help enhance the educational level in the mountainous area. Education enhancement will have multiple benefits to the residents in the mountainous area and in the end improve the overall health of the population.

The high percentage of alcohol consumption in women in the mountainous area is a serious problem, not just for obesity but also for overall health. Providing more health education to this unique area is urgent.

The fact that life expectancy at birth of aborigines is ten years less than that of general Taiwanese is evidence of social inequality in health in Taiwan. Obesity is one of the issues. From this study, educational level and area of residence were strong predictors of BMI. This result implies that obesity can worsen the problem of social inequality in health in Taiwan. More studies of obesity should focus on the influence of socioeconomic status, considering biological factors, dietary factors, and lifestyle factors simultaneously. Understanding how social and economic factors in the mountainous area have led to an unsupportive environment to weight management and good health will help make equitable public health policies, and develop effective community-based comprehensive health education programs. Also, more studies on minority health and public policy on eliminating social inequality in health are needed.

Table 27

Summary of this Study

Research Question 1 to 3

Predictors of BMI	All Participants	Men	Women
Age (per year)	0.113	0.102	0.122
Senior High School Education[a]	-1.373	N.S.[c]	-2.017
Mountainous Area[b]	3.143	2.560	3.563

[a] Reference: primary school education or no education [b] Reference: western area
[c] Not significant

Research Question 4

Participants with alcohol consumption behaviors had a significantly higher BMI than that of participants without alcohol consumption behaviors (Mean difference: -0.581 kg/m^2, p=0.0095).

Research Question 5

68% of women in the mountainous area had alcohol consumption behaviors, significantly higher than other areas (p<0.0001).

Research Question 6

Area of Residence	BMI[1]	Leisure Time Physical Activity[2]	Nutrition Knowledge Score[3]
Western Area	22.49[ac]	47.27[df]	7.16[gi]
Mountainous Area	24.97[ab]	83.20[de]	6.28[gh]
Eastern and Islands Area	23.18[bc]	71.80[ef]	6.77[hi]

Note: LSMean with same superscripts were significantly different, p<0.05
[1] Unit: kg/m^2 [2] Unit: kcal/kg/month [3] Unit: points (range from 0 to 9)

Research Question 7

Smokers had significantly higher energy intake than that of non-smokers at an alpha level of .05.

6.2 Recommendations for Future Studies

As discussed in Chapter 5, some measurement issues and extraneous factors might improve this study for predicting BMI. Therefore, recommendations for future studies include: (1) Household income or personal income could be added to the predicting model of BMI. (2) Occupation could be added to the model based on energy expenditure. (3) Measurement of dietary intake should reduce the random fluctuation in day-to-day intake and improve the accuracy of response. At least three consecutive 24-h dietary recalls are recommended. Household food intake inventory or telephone interview could be used simultaneously to double-check the accuracy of response. Revisits are recommended if necessary. (4) Measurement of physical activity could collect more detailed information such as the intensity, type, frequency, and duration if possible. Athletes should be separated from ordinary persons. (5) Cross-sectional study and longitudinal study could be complementary.

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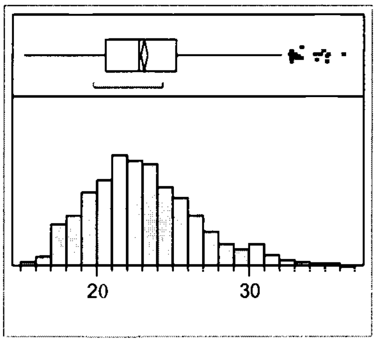
APPENDICES

APPENDIX 1

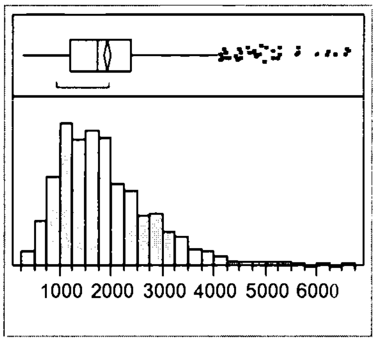
DISTRIBUTIONS OF CONTINUOUS VARIABLES

Distribution of BMI



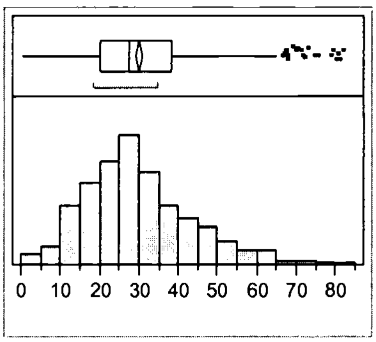
Quantiles			Moments	
100.0%	maximum	36.239	Mean	23.132618
99.5%		34.990	Std Dev	3.6542822
97.5%		31.479	Std Err Mean	0.1082305
90.0%		28.028	upper 95% Mean	23.344975
75.0%	quartile	25.238	lower 95% Mean	22.920261
50.0%	median	22.776	N	1140
25.0%	quartile	20.534	Sum Wgts	1140
10.0%		18.766	Sum	26371.185
2.5%		17.246	Variance	13.353779
0.5%		15.869	Skewness	0.6521263
0.0%	minimum	15.234	Kurtosis	0.4039861
			CV	15.797098

Distribution of Energy Intake



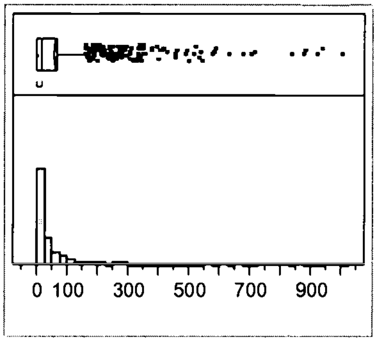
Quantiles			Moments	
100.0%	maximum	6639.3	Mean	1923.5577
99.5%		6221.8	Std Dev	993.53675
97.5%		4515.7	Std Err Mean	29.47778
90.0%		3225.3	upper 95% Mean	1981.3957
75.0%	quartile	2383.7	lower 95% Mean	1865.7196
50.0%	median	1719.7	N	1136
25.0%	quartile	1216.9	Sum Wgts	1136
10.0%		904.5	Sum	2185161.5
2.5%		608.4	Variance	987115.28
0.5%		322.3	Skewness	1.4217589
0.0%	minimum	292.8	Kurtosis	2.9965159
			CV	51.650999

Distribution of Fat Intake Percent



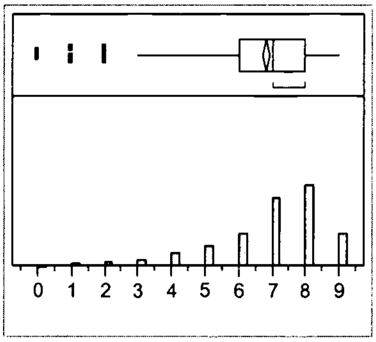
Quantiles			Moments	
100.0%	maximum	82.335	Mean	30.07841
99.5%		79.358	Std Dev	14.1162
97.5%		63.233	Std Err Mean	0.4188212
90.0%		49.199	upper 95% Mean	30.900175
75.0%	quartile	38.143	lower 95% Mean	29.256645
50.0%	median	27.597	N	1136
25.0%	quartile	20.237	Sum Wgts	1136
10.0%		13.899	Sum	34169.074
2.5%		7.158	Variance	199.26711
0.5%		2.437	Skewness	0.7717697
0.0%	minimum	0.289	Kurtosis	0.7128253
			CV	46.931338

Distribution of Leisure time Physical Activity



Quantiles			Moments	
100.0%	maximum	1008.0	Mean	61.587938
99.5%		844.6	Std Dev	116.73397
97.5%		399.8	Std Err Mean	3.4025854
90.0%		176.8	upper 95% Mean	68.263868
75.0%	quartile	64.5	lower 95% Mean	54.912008
50.0%	median	18.0	N	1177
25.0%	quartile	0.0	Sum Wgts	1177
10.0%		0.0	Sum	72489.003
2.5%		0.0	Variance	13626.82
0.5%		0.0	Skewness	3.8247496
0.0%	minimum	0.0	Kurtosis	19.177115
			CV	189.54032

Distribution of Nutrition Knowledge Score



Quantiles			Moments	
100.0%	maximum	9.0000	Mean	6.8383751
99.5%		9.0000	Std Dev	1.7668556
97.5%		9.0000	Std Err Mean	0.0519439
90.0%		9.0000	upper 95% Mean	6.9402917
75.0%	quartile	8.0000	lower 95% Mean	6.7364585
50.0%	median	7.0000	N	1157
25.0%	quartile	6.0000	Sum Wgts	1157
10.0%		4.0000	Sum	7912
2.5%		2.0000	Variance	3.1217787
0.5%		0.0000	Skewness	-1.244007
0.0%	minimum	0.0000	Kurtosis	1.5560622
			CV	25.83736

APPENDIX 2

CORRELATION MATRIX

Correlations

	BMI	AGE	SEX	High School	Junior High	Mountain	Eastern	Smoking	Alcohol	Energy Cost	Energy Intake	Fat %	Knowledge
BMI	1	0.2721	-0.0663	-0.2508	0.0451	0.3135	0.0156	0.0843	0.0848	0.0446	0.047	-0.0139	-0.1804
AGE	0.2721	1	-0.0283	-0.2509	-0.0999	-0.002	0.0279	-0.0139	-0.042	-0.007	0.0234	0.0277	-0.0882
SEX	-0.0663	-0.0283	1	-0.1613	0.0255	0.0104	0.0116	-0.5889	-0.3972	-0.1416	-0.3147	0.1379	0.0016
High School	-0.2508	-0.2509	-0.1613	1	-0.559	-0.1333	-0.0658	0.0468	0.0759	0.0482	0.0875	0.0358	0.4125
Junior High	0.0451	-0.0999	0.0255	-0.559	1	0.0169	0.0159	0.0486	0.0596	-0.0618	0.0078	0.0309	-0.0648
Mountain	0.3135	-0.002	0.0104	-0.1333	0.0169	1	-0.2471	0.058	0.1081	0.1596	-0.0067	-0.0063	-0.2336
Eastern	0.0156	0.0279	0.0116	-0.0658	0.0159	-0.2471	1	-0.0242	-0.0185	0.0429	0.0674	-0.0194	-0.0801
Smoking	0.0843	-0.0139	-0.5889	0.0468	0.0486	0.058	-0.0242	1	0.4049	0.0758	0.2531	-0.0388	-0.0449
Alcohol	0.0848	-0.042	-0.3972	0.0759	0.0596	0.1081	-0.0185	0.4049	1	0.0726	0.1642	-0.0483	-0.0236
Energy Cost	0.0446	-0.007	-0.1416	0.0482	-0.0618	0.1596	0.0429	0.0758	0.0726	1	0.1138	0.0377	-0.0471
Energy Intake	0.047	0.0234	-0.3147	0.0875	0.0078	-0.0067	0.0674	0.2531	0.1642	0.1138	1	0.3282	0.0264
Fat %	-0.0139	0.0277	0.1379	0.0358	0.0309	-0.0063	-0.0194	-0.0388	-0.0483	0.0377	0.3282	1	0.027
Knowledge	-0.1804	-0.0882	0.0016	0.4125	-0.0648	-0.2336	-0.0801	-0.0449	-0.0236	-0.0471	0.0264	0.027	1

113 rows not used due to missing values.

Correlations

	BMI	Education	Residence	Smoking	Alcohol	Energy Cost	Energy Intake	Fat %	Knowledge
BMI	1	-0.2742	0.1408	0.0843	0.0848	0.0446	0.047	-0.0139	-0.1804
Education	-0.2742	1	-0.1479	0.0696	0.114	0.0352	0.1106	0.0633	0.467
Residence	0.1408	-0.1479	1	-0.0017	0.0242	0.1074	0.0662	-0.0223	-0.1748
Smoking	0.0843	0.0696	-0.0017	1	0.4049	0.0758	0.2531	-0.0388	-0.0449
Alcohol	0.0848	0.114	0.0242	0.4049	1	0.0726	0.1642	-0.0483	-0.0236
Energy Cost	0.0446	0.0352	0.1074	0.0758	0.0726	1	0.1138	0.0377	-0.0471
Energy Intake	0.047	0.1106	0.0662	0.2531	0.1642	0.1138	1	0.3282	0.0264
Fat %	-0.0139	0.0633	-0.0223	-0.0388	-0.0483	0.0377	0.3282	1	0.027
Knowledge	-0.1804	0.467	-0.1748	-0.0449	-0.0236	-0.0471	0.0264	0.027	1

113 rows not used due to missing values.